PATENT SPECIFICATION

DRAWINGS ATTACHED

1,149,923

1,149,923

Date of Application and filing Complete Specification: 1 July, 1966.
No. 29576/66.
Complete Specification Published: 23 April, 1969.

Index at acceptance:—B3 A(124, 158); B3 R(6, 17B, 33, 36, 37A1A, 37A1E)
Int. Cl.:—B 21 d 53/04

COMPLETE SPECIFICATION

Improvements in or relating to Methods of Manufacturing Lamellae for Heat Exchangers

I, KARL STEN-BERTIL LUNDBERG, of Sturevagen 16, Stocksund, Sweden, formerly of Via S. Maria alla Porta 9, Milan, Italy, a subject of the King of Sweden, do hereby declare the invention, for which I pray that a Patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

THIS INVENTION relates to a method of manufacturing lamellae for heat exchangers and to the lamellae manufactured by the method.

More exactly stated, the invention relates to lamellae for the type of heat exchanger where a bundle of parallel lamellae incorporating narrow ducts of a plane configuration are built in a shell extending over the whole length of the heat exchanger. When the lamellae are mounted in a shell of this type, they are normally disposed in such a way that a certain number of lamellae are placed in one plane adjacently and several planes of this type are mounted at a certain distance from the other planes in parallel, filling up the whole cross-section of the shell with that number of plates of lamellae which is considered useful. For technical reasons, the ducts which has a narrow and plane form cannot be made in any width, since they might be too susceptible to distortion by the pressure of the product which passes inside the lamellae. For this reason it is preferable to divide the duct in each lamella into two or more ducts in the same plane.

It is obvious, for reasons of standardization, that one tries to use the smallest possible number of different forms of lamella, consistent with covering as fully as possible the varying chordal distances between the walls of the shell. In practice, a range of three or four principal measurements of lamellae is satisfactory for almost all conditions.

The lamella with the smallest width can even have just one single duct, the others two, and in certain cases even several ducts of the same or variable width. Of course, there might also be other types but with those indicated as above generally it is possible to reach quite satisfactory results.

Hitherto the lamellae have been manufactured in the following way. Two plain sheets of the length of the required lamella are profiled longitudinally in such a way as to create concavities corresponding to the ducts. Two sheets profiled in this way are joined together in such a way that the concavities are to be found opposite one another, thus forming the ducts in the lamella. Another method consists in covering a single sheet profiled as above with a plain sheet of material. The sheets joined in this way are then welded together by resistance seam welding. The sheets are welded together with one or more parallel welds in the space between the ducts in such a way as to separate completely the ducts one from another. The lamella obtained in this way can have various total widths reaching even quite large measurements, and the ducts can have the same or different widths following the various requirements. From these assemblies of sheets welded together the lamellae of the desired widths are afterwards cut out by sawing in down the welds or between two adjacent welds parallel to the ducts. The profiling work constitutes a fast operation, while the welding, on the other hand, requires much more time. In order to utilise one single profiling machine efficiently it is consequently necessary to have a plurality of welding plants.

The lamella created as stated above presents all along the free borders a protrud-

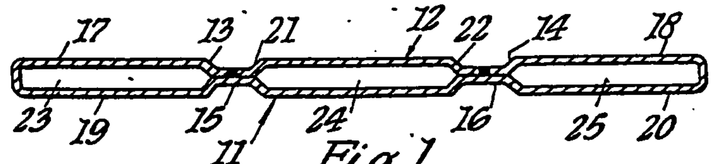

Fig.1.

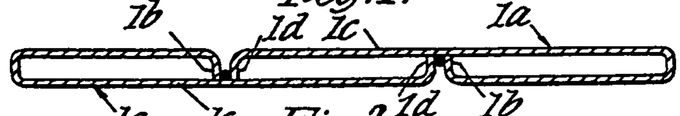

Fig.2.

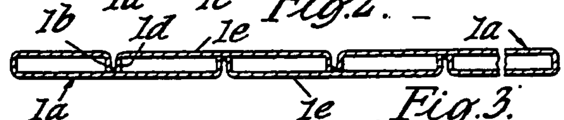

Fig.3.

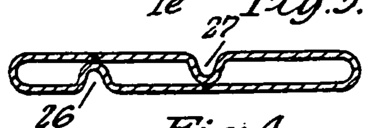

Fig.4.

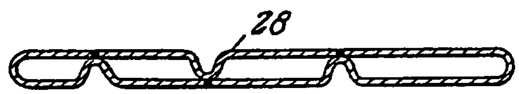

Fig.5.

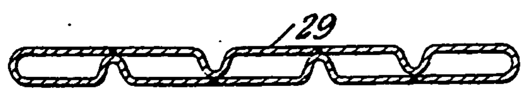

Fig.6.

Fig.7

1149923 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheets 1 & 2

Fig.8.

Fig.11

Fig.12.

Fig.9.

Fig.10.

Fig.13.

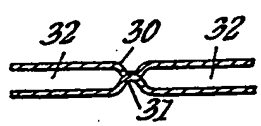

Fig.14.

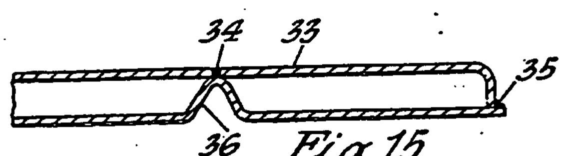

Fig.15.

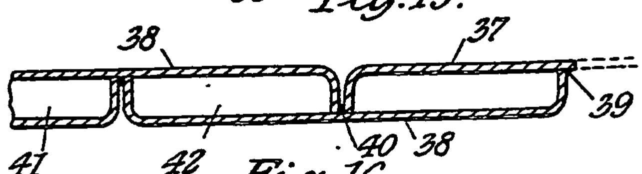

Fig.16.

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2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheets 1 & 2

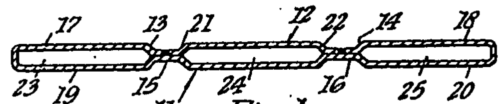

Fig.1.

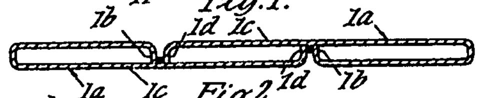

Fig.2.

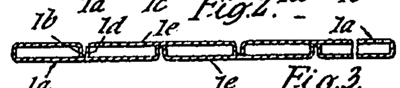

Fig.3.

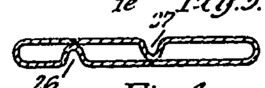

Fig.4.

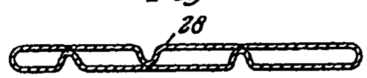

Fig.5.

Fig.6.

Fig.7

Fig.8.

Fig.9.

Fig.10.

Fig.11

Fig.12.

Fig.13.

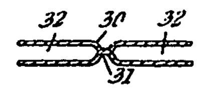

Fig.14.

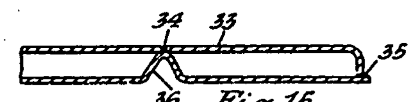

Fig.15.

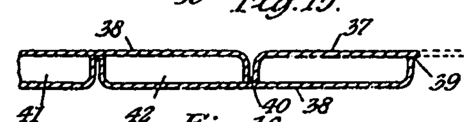

Fig.16.

ing edge formed by those parts of the sheets which are joined and welded together. From the point of view of heat exchange, these edges constitute parts of the lamella which have a reduced efficiency, and this is also true as regards the welds between the ducts in the lamella. Because of the edges along the borders of the lamellae it is not possible to place the lamellae with the ducts close to the walls of the shell. This reduces the capacity of the heat exchanger for given space requirements. Also, the spaces occupied by the welds between the ducts have the effect of increasing the dead spaces in the heat exchanger.

This invention is made with the aim of creating a new type of lamella and a method manufacturing the lamella, eliminating or mitigating the disadvantages set out above. The manufacturing method as per the invention constitutes also a simplification of the working operations and makes possible a reduction in the manufacturing costs, in that it will be possible to use much simpler machinery than that required with present methods.

The thermo-technical advantages of the invention consists in the following:— It is possible to utilise better the material for direct heat exchange, eliminating or reducing the edges along the lamella and the spaces between the ducts in the lamella. The lamellae can be positioned closer to one another on the same plane as well as more closely to the walls of the shell, thus attaining a more efficient utilization of the shell volume.

The advantages of the invention from a flow technique point of view are determined by the fact that at a given total section of the ducts in the lamella one can obtain a corresponding shell section which is much smaller than previously possible, i.e. one can avoid the creation of dead spaces as a result of the fact that the edges and spaces between the ducts are practically eliminated.

The advantages of the invention from the manufacturing point of view consist, firstly, in the fact that it is possible to use welding methods that are less costly; for example, arc welding or gas welding in substitution for resistance seam welding. The last mentioned type of welding requires machinery which is much more expensive than that which is required for arc welding or gas welding. Secondly, it is possible to reduce the number of longitudinal welds. Thirdly, the simplified welding and the reduction of the welding work lead to a saving of time and also to the possibility of utilising the profiling plant more efficiently and continuously. Fourthly, the new form of the lamellae practically without edges and with the very small spaces between the ducts simplifies considerably the operation of joining the lamellae at the headers of the bundles, which operation previously was very time-consuming. The degree of difficulty was increased by the presence of edges or welding spaces.

The method according to the present invention for the manufacturing of lamellae is characterised in that at least one sheet of material is profiled to form at least one longitudinal concavity of which the surface on the concave side co-operates with at least two distinct opposite walls in the creation of at least two ducts in the said lamellae, the said opposite walls being part of two distinct sheets, one of which may be the said at least re sheet the free edges of the said opposed walls being brought together and joined together and to the surface of the concave side of said concavity in onen single operation in an intermediate zone of said surface.

Introducing another element between the edges of the first element which are bent over, it is possible to create a lamella with three ducts, just as introducing further adjacent elements between the bent over edges of the first element it is possible to obtain lamellae with correspondingly more ducts. In all cases the weld is made joining in one operation the adjacent borders of the elements together and simultaneously with the opposite wall.

The invention further consists in a method of manufacturing a lamella for a heat exchanger, in which the lamellae are divided into a plurality of ducts and are made up from sheets of material in which the free edges of the lamellae are formed by 180° bends in single sheets and the intermediate divisions between ducts are formed by joining in a single welding operation two sheet edges and an intermediate zone of a sheet forming one wall of each of a pair of adjacent ducts.

The preferred method for the mechanical forming of the sheet material is profiling in a profiling plant with rollers. It is also possible to confer the desired forms to the material profiling by means of lamination, pressing or bending.

The forming operations are completed before the subsequent welding operation. After the welding, further working operations on the lamella are not necessary. After the welding operation the lamella is in its final for installation as part of a form heat exchanger.

In those cases where the material cannot be formed by a mechanical operation, for instance cast iron, the elements to be welded together may be obtained by casting. Where it is too difficult to obtain the bending over of the material along the edges of the lamella owing to the characteristics of the material, the ducts along the borders may be covered by strips of material which are welded onto the edges of the lamella.

Further characteristics of the invention become evident from the following description with reference to the accompanying drawings, which are referred to by way of example only

and without any limitation as to the practical use of the invention.

In the drawings:

Figure 1 shows in section a lamella with three ducts made according to one form of the invention;

Figure 2 shows a lamella with three ducts obtained according to another form of the invention;

Figure 3 shows a variation of the structure of figure 2;

Figure 4 shows a lamella with three ducts with different sections;

Figure 5 shows a lamella with four ducts with different sections;

Figure 6 shows a lamella with five ducts with all the sections equal;

Figures 7—14 show various ways of effecting the weld in order to join the free edges to the opposite wall.

Figure 15 shows a section of a lamella in which the edge ducts have been obtained by a method according to this invention; and

Figure 16 represents a section of a different form of lamella where the edge ducts have been obtained by a method according to the invention.

Figure 1 shows a lamella with three ducts formed by two sheets of material 11 and 12. Both sheets of material are firstly profiled. The larger sheet of material 11, i.e. the lower one, has been bent in such a way as to have a concavity in the central part between the extreme edges of the lamella, while the outer parts have been bent at 180° along lines that correspond substantially with the edges of the lamella. In this way the free edges, 13 and 14, of the sheet of material 11 are brought into contact with edges 15 and 16 of a central part of the concavity. The plane parts 17 and 18 bent towards the centre of the lamella will normally be parallel to plane parts 19 and 20 of the sheet. The other sheet of material 12 is formed in such a way as substantially to enter into contact with the edges 13 and 14, thus covering the central part of the concavity in the sheet 11. Edges 21 and 22 of the sheet of material 12 are slightly bent in order to meet the edges 15 and 16, allowing the plane part of the sheet 12 to remain on the same line as the plane parts 17 and 18. The two longitudinal edges 13 and 21, and the edge 15, as well as edges 14 and 22, and edge 16 respectively, are welded together, at which stage the lamella with three ducts, 23, 24 and 25 is finished.

Figure 2 shows a lamella with three ducts made up from two identically bent sheets 1a each bent at 180° to form one end of the lamella, and each with one edge 1b bent 90° to to the middle of the plane zone 1c. The second edge 1d, is bent 90° and is welded to the middle of the plane zone 1c and the edge 1b of the other sheet. The space between the 180° bend and the edge 1d constitutes a concavity which is divided into two ducts by the edge 1b and the edge 1d of the opposite sheet.

Figure 3 shows the construction of a lamella of n ducts, with $n-1$ pieces of material and $n-1$ welds quite analogous to the construction of Figure 2 with the addition of intermediate sheets 1e terminating in edges such as 1d.

Figure 4 shows a lamella with three ducts obtained with two sheets bent along one side only and positioned one on top of the other in overlapping relationship. The profiling of the pieces as regards the location of depressions 16 and 27 has been effected in such a way as to give different widths to the three ducts of the lamella.

Figures 5 and 6 show lamellae with four and five ducts respectively, and also respectively with different sections and with equal sections obtained by an intermediate sheet indicated by the numeral 28 in Figure 5 and by the numeral 29 in Figure 6 profiled with a central depression.

Figures 7—14 show various forms of the edge welds in order to form ducts in the lamellae.

Figures 7 and 8 show how the welding may be achieved by bending the free edges down to the interior of the concavity, or alternatively depressing the concavity outwardly towards the free edges. In Figures 7 and 8, the bending is by having an inclined portion and then a short portion parallel with the wall to which the weld is made. Figure 9 shows a straight forward down bending of the free edges, and Figure 10 shows a down bending which is inclined to the normal to the wall to which the edges are to be welded. Figure 14 shows a combination of the normal down bending of Figure 9, with a very short portion parallel to the wall, and Figure 12 shows a variation of Figure 8 with steeper inclinations. Figure 13 shows an arrangement similar to that of Figure 9 but with the down bent portions closer together with the weld performed from the outside of the concavity. Figure 14 shows a combination type of weld in which the two free edges are bent down as indicated at 30 towards a protrusion 31 extending for part of the height of the ducts 32. The relationship between the relative depth of the proportions 30 and height of the protrusion may be chosen at will to suite the desired conditions.

In all the variants as per Figures 7—14, the welding method to be preferred is short arc welding, though it is possible to use "spray" welding. Also, tungsten-arc welding without filler material gives good results, as does welding with ultrasonics.

With reference to Figure 15, the duct along the outer edge of the lamella is completed by a profiled sheet 33 in which one of its edges is welded at 34 on the top of the convexity

36 and with the other edge is welded at point 35 to the free edge. The divisions between adjacent ducts may be at any of the types previously described.

In Figure 16 it is possible to see that the methods according to the invention allow a constructional variation of the outer duct of the lamella, particularly in the case where the lamella is made up of several identical pieces positioned in oposition with their edges in contact with an intermediate zone of the opposite pieces.

In this case the end duct is obtained adding a sheet 37 which is merely an element that contributes to the creation of the lamella in the same way as the pieces 38 but with a part of it cut off (as indicated dotted), in order to close the end duct with welds 39 and 40.

The division of the concavities of the lamellae 41 and 42 into ducts are obtained with elements 38 placed in opposition with the edges touching an intermediate zone of the opposite wall.

As it becomes evident particularly from Figures 15 and 16, the methods according to the invention allow for the use of materials, for instance cast iron, which even though they have not good mechanical working properties, have on the other hand advantages from the point of view of thermal transmisison as well as from an economic point of view.

At this point it should be stressed that the method of effecting the welding represents a determining characteristic of the invention, and this at least as regards the two following aspects:—

1. It is possible to join together the two free edges in one single welding operation and at the same time these two edges are joined with the opposite wall of the lamella. This operation has the advantage of reducing the number of welds. In the methods used up to now there has always been one more weld than the number of ducts in the lamella, while the invention makes it possible to create the lamella with a number of welds that can be, as shown previously, one less than the number of ducts. In the ideal case, that is a lamella with two ducts which is very often used, this leads obviously to a reduction of the welding work by approximately two thirds.

2. The method of assembling the parts of the lamella allows for a wide choice of welding methods. Up to now it has been necessary to use resistance seam welding. Apart from the fact that the related plant is costly (also because of the considerable welding currents involved with requirements for big power plants, transformers, etc.), the space in the lamella occupied by the resistance seam welds is large, much larger than is required, for instance, with arc welding. The old method causes on the one hand loss of material and on the other hand a reduction in efficiency in quite a considerable part of the material. For instance, in order to create a duct for an internal pressure of 143 p.s.i. (10 kgms./cm.2) or more, it is not possible to use ducts larger than 22—25 mm., while the welds of one on each side of the duct occupy a width of 9—10 mm.; consequently up to 25—30% of the material in the lamella is taken up by space for the welds, i.e. it cannot be utilised in the creation of ducts, with a reduction up to 50% of its efficiency as regards the thermal transmission. In addition to this, when applying the methods known up to now, the flow conditions for the fluid passing in the shell become much less favourable given the fact that correspondingly to all those welds empty spaces are formed which often are to be considered dead spaces as far as the thermal transmission is concerned.

All these inconveniences are eliminated with the manufacturing methods according to the present invention.

WHAT I CLAIM IS:—

1. A method of manufacturing of lamellae for heat exchangers of the type comprising a bundle of parallel lamellae with plane and narrow ducts mounted in a shell, characterised in that at least one sheet of material is profiled to form at least one longitudinal concavity of which the surface on the concave side co-operates with at least two distinct opposite walls in the creation of at least two ducts in the said lamella, the said opposite walls being parts of two distinct sheets, one of which may be the said at least one sheet, the free edges of the said opposed walls being brought together and joined together and to the surface of the concave side of said concavity in one single operation in an intermediate zone of said surface.

2. Method as claimed in claim 1, characterised in that said intermediate zone of the surface of the concave part of the said at least one longitudinal cavity profiled in the said sheet has an essentially ridge-like configuration with its convexity orientated towards said opposite walls.

3. Method as claimed in claim 1 characterised in that said walls placed in opposition and co-operating with said surface of the concave side of said at least one longitudinal concavity include a second sheet of profiled material placed in intermediate position longitudinally between edge parts of said sheet which are bent substantially at 180°, the edges of said bent parts being joined to the adjacent edges of said second sheet and to intermediate zones of the surface of the concave part of said cavity, creating a lamella with three ducts.

4. Method of manufacturing a lamella for a heat exchanger, in which the lamellae are divided into a plurality of ducts and are made

up from sheets of material, in which the free edges of the lamellae are formed by 180° bends in single sheets and the intermediate divisions between ducts are formed by joining in a single welding operation two sheet edges and an intermediate zone of a sheet forming one wall of each of a pair of adjacent ducts.

5. Method as claimed in claim 4, characterized in that said intermediate zones of said sheets elements along which the longitudinal joint is effected have an essentially ridge-like configuration with the convexity turned towards said free edges.

6. Method as claimed in claim 5, characterised in that the ducts along the sides of a lamella are obtained by welding the edges of the sheets bent at 180° along the adjacent ridge like configurations.

7. Method for the fabrication of lamellae for heat exchangers characterised in that the divisions between adjacent ducts in the lamella are formed by a method as claimed in claim 1, and in that the outer ducts are completed by superimposing a profiled piece of material joined by welding at the free edges of the lamella.

8. Lamella for heat exchangers in general, characterised in that it is manufactured in accordance with the method as claimed in any of the preceding claims.

9. A method for the manufacture of lamellae for heat exchangers substantially as hereinbefore described with reference to the accompanying drawings.

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Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1969.
Published by the Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies may be obtained.